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Stopping rules for majority voting: A public choice experiment☆

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ABSTRACT

Some solution concepts make the same equilibrium prediction regardless of how voting ends. As a result, experimentalists have used a variety of stopping rules without carefully considering the consequences. This experiment compares majority decision making in committees using one of three stopping rules: vote by a majority to adjourn, a fixed time period, and the chair decides when to adjourn. We compare these rules for groups of five subjects using two distributions of ideal points studied by Fiorina and Plott (1978). Although we find few differences between voting to adjourn and ending after a fixed time period, we find noticeable differences between groups with the chair decides to adjourn and those without. Allowing the chair to determine adjournment produces outcomes more favorable to the chair and can make the voting process continue for more than three times as many rounds as the other two treatments. Such results should help committees improve the rules governing their decisions.

1. Introduction

This year marks the 40th anniversary of Fiorina and Plott's seminal work "Committee Decisions under Majority Rule: An Experimental Study." In this work, the authors evaluate whether subjects adhere to Plott's (1967) theory about the core in spatial voting games.[1] The work was so groundbreaking that it inspired a series of experiments in the field of Public Choice. Scholars have since used Fiorina and Plott's design to evaluate the stability of equilibria (Sauermann, 2016), the effects of closed rules (Kormendi and Plott, 1982), and various conjectures about fairness in committees (Eavey, 1991; Grelak and Koford, 1997; Sauermann and Kaiser, 2010). However, they have paid little attention to the effects of stopping rules on policy outcomes. Stopping rules dictate how voting in a forward agenda ends.[2]

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[1] The core is the set of alternatives that cannot be defeated using a specified voting rule. For example, alternative x is an element of the majority rule core if there does not exist another alternative y that a majority of voters prefer to x.

[2] A forward agenda begins with a proposal to amend the status quo (the policy we have now). If the proposal wins, it becomes the new status quo, and further amendments can be proposed. The process continues until voting is halted by a stopping rule. The alternative that wins in the final round is the collective choice.

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This paper fills that gap. It replicates (Fiorina and Plott, 1978) experiment while manipulating the stopping rule. Fiorina and Plott ask subjects to propose and vote on alternatives until someone in their group motions to adjourn and a majority of the group accepts the proposal to stop voting. The stopping rules we consider are vote to adjourn, timed voting, and chair decides to adjourn, which we compare using two configurations of ideal points: one that meets the Plott conditions and one that does not.[3]

We find that the type of stopping rule used by a committee can impact the decisions it makes. Although we find few differences between vote to adjourn and timed voting, we find noticeable differences between those treatments and the chair decides to adjourn. Allowing the chair to determine adjournment produces more favorable outcomes for the chair and can make the voting process continue for more than three times as many rounds as the other two treatments. Nevertheless, chairs that hold their groups hostage to more rounds of voting do not produce outcomes closer to their ideal points. Such results hold true for both the Plott and non-Plott configurations of ideal points studied here.

2. Literature

A forward agenda begins with a proposal to amend the status quo. If the proposal passes, it becomes the new status quo in the next round. If it fails, the current status quo carries forward. The process continues until voting is halted using a stopping rule. Experiments on forward agendas are common in Public Choice. Perhaps the most seminal work in the field is Fiorina and Plott's (1978) test of the majority-rule core as a prediction for majority decision making. Fiorina and Plott ask groups of five subjects to select a point on a blackboard using series of majority votes. Each subject is given an ideal point in the space and a payoff function that gives them greater payoffs from outcomes closer to their ideal point than outcomes farther away.[4] Any subject can propose an alternative if they raise their hand and are recognized by the experimenter. Proposing and voting ends when a majority vote to adjourn. Fiorina and Plott find that groups end the experiment at the majority-rule core, or a point near the core. If the core is empty, groups arrive at points surprisingly close to the same point (i.e., they end close to the previous point even though it is no longer in equilibrium). Communication among group members has little effect on the results.

Fiorina and Plott's (1978) work inspired a series of experiments on forward agendas, with different stopping rules. These rules include stopping when the committee votes to adjourn, stopping after a fixed time period (or a fixed number of rounds), and stopping when a "committee chair" decides to adjourn. Experimentalists have used these three stopping rules without fully considering how it affects their results.

With vote to adjourn, committees continue voting on proposals until a majority of members agree to stop voting. This has been applied in several ways. Fiorina and Plott (1978), McKelvey and Ordeshook (1984a), and Bottom et al. (1996) allow any subject on the committee to motion to adjourn at any time, which immediately results in a vote to adjourn. If a majority of subjects agree to adjourn, voting ends and subjects are paid based on the last alternative agreed upon.

In their small group sessions, Bianco et al. (2008) give a random committee member 90 seconds to either make a proposal, propose to adjourn, or to pass the right to propose to another randomly chosen subject. They stopped their large group sessions the same way as Fiorina and Plott (1978). They claim that the difference in their stopping rules may explain why their small groups, on average, made more substantive proposals than their large groups (2008, 123, n. 8).

With fixed time or a fixed number of rounds, committees continue voting for a predetermined time or a predetermined number of rounds that all players know in advance. When the limit is reached, voting ends and subjects are paid based on the outcome chosen in the final round. This type of stopping rule occurs at the end of a legislative session in what Robert's Rules of Order calls an "adjournment without day." Bills assigned to committees by the government in Finland, Ireland, and the United Kingdom may require similar time limits (Döring, 995, p. 237-8).

The advantage of this rule is that it makes the termination of voting more predictable. Dougherty and Edward (2012) prove that if information is complete, individuals propose and vote strategically, the number of rounds is finite (or the final round known through a time limit), and indifferent voters vote in favor of proposals, then any k-majority rule will produce a Pareto optimal outcome in subgame perfect equilibrium. Dougherty et al. (2014) test the conjecture and find that groups are more likely to attain Pareto optimal outcomes using majority rule than unanimity rule. Other scholars have used a fixed number of rounds in their research as well, varying from six rounds (McKelvey and Ordeshook, 1984b) to twenty (Sauermann, 2016, 2017).

Miller et al. (1996) use timed stopping instead of a fixed number of rounds. They choose a 30 min time limit to "control the impact of differential opportunity costs among the subjects," namely a desire to leave the experiment (1996, 102-3, n. 3). They find that a bicameral core predicts well in this setting.

A third rule found in the experimental literature with real-world applications is the chair decides to adjourn. With chair decides to adjourn, a committee continues to vote until the chair, a voting member, decides voting should end. In practice, strong mayor-council forms of government have used this rule (Georgia, 2012), monarchs and prime ministers have used it to prorogue parliament (Dimitruk, 2018), and chairs overseeing multilateral bargains have used stronger versions (Tallberg, 2010).

[3] Loosely, the Plott conditions are satisfied if and only if ideal points are distributed in a radially symmetric fashion around a policy x^* where x^* is a voter's ideal point. See Munger and Munger (2015) for an introduction to these and other concepts.

[4] An ideal point is the point in the space that gives a subject maximal payoff.

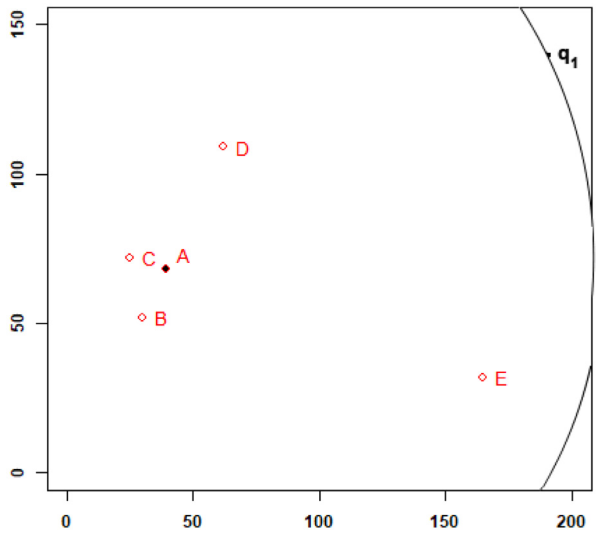

Fig. 1. Series 1 Ideal Points and the Initial Status Quo. *Note:* in this figure A, B, C, D, and E are ideal points, and q_1 is the initial status quo.

Haney et al. (1992) use chair decides to adjourn to show the effect of advisors on a leader's decisions. In one of their treatments, advisors make amendments that are voted upon by the advisors. If an amendment passes, the leader either accepts or rejects the amendment. The advisors then make a new round of amendments in the next round. The process repeats until the leader chooses to adjourn (also see Altfeld and Miller, 1984; and Eavey and Miller, 1984).

Finally, it should be noted that experiments on forward agendas can be loosely related to experiments on the Baron-Ferejohn bargaining model (Baron and Ferejohn, 1989; Frechette and Vespa, 2017; McKelvey, 1991; Miller and Oppenheimer, 1982; Miller and Vanberg, 2013). In those experiments, players are recognized as proposers with specific probabilities. If their proposal passes, the game ends and players receive payoffs based on the proposal. If the proposal fails, a new proposer is recognized and the game continues until another proposal passes. If no alternative is ever accepted, each player receives a payoff of zero. An important difference between bargaining experiments and the forward agenda experiments studied here is that groups cannot wander around the space producing different status quos in standard bargaining games. They also receive zero utility for failing to pass any proposal rather than positive utility from the status quo. Furthermore, discounting is often manipulated in bargaining experiments by reducing the size of the payoffs in each round. Although subjects can be impatient in forward agenda games, such as ours, discounting is not typically manipulated because it has no effect on the core nor several other solution concepts applied to spatial voting.

3. Theory

We believe the choice of stopping rule can affect rational action and produce different results. This does not put us at odds with theoretical work on the core. It only suggests that the standard core prediction applies to pure majority rule and is not sensitive to small institutional variations. Other game theoretic concepts, or core predictions that account for these institutions, might be better applied when stopping rules are included in the analysis.

We consider two distributions of ideal points, Series 1 and Series 2, which correspond to Fiorina and Plott's (1978) Series 1 and Series 3. The first meets Plott's (1967) conditions for a non-empty, majority-rule core (i.e., an equilibrium). In this series, Player A's ideal point is the k-dimensional median located at the intersection of two line segments – one connecting C's and E's ideal point, the other connecting B's and D's ideal point (see Fig. 1). It is an equilibrium in the sense that there does not exist another point that a majority prefer to it. The second series moves Player A's ideal point a small distance southeast, creating an empty core (i.e., no equilibrium under majority rule). Although Plott conditions may be rare in practice, we focus our attention on Series 1 because it yields clear theoretical predictions for all three of our treatments.

Equilibria depend on the rules of the game. In all of our treatments a player is randomly recognized as proposer with equal probability and can propose any point in the space including the status quo. After a proposal is made, members of the committee vote for the proposal or for the status quo. They then enter a phase where the group decides whether to adjourn, and the process repeats if the group does not adjourn.

In our first treatment, Vote to Adjourn (VTA), any player can propose to adjourn after their group has voted. If a majority chooses to continue, players move to the next round and the process of proposing and voting repeats. If a majority chooses to adjourn, voting ends and subjects are paid based on the distance between their ideal point and the outcome adopted in the previous round.

We expect that groups using VTA will continue voting until the majority-rule core is reached (i.e., until the group selects point A). If they stopped at any other point, a majority of players would receive more points by continuing to A. Once A is attained, a majority would have no incentive to leave that location. Hence, if subjects care only about maximizing points, groups should not adjourn until they reach the majority-rule core.

Our second treatment, Timed Stopping Rule (TSR), stops voting after a fixed period of time (15 min). We expect that TSR should produce different outcomes than VTA because each player knows exactly when play stops. Using backward induction, it would be rational for the last proposer to propose either the point closest to their ideal point that is in the winset of the status quo, or propose the status quo if it is closer. Anticipating this, the very first proposer should wait until time has almost expired, then propose the point closest to their ideal point in the winset of the initial status quo, q_1. That winset is bounded by the two arches in Fig. 1. Since all of the ideal points are in the winset of q_1, subjects should wait until time is about to expire, propose their own ideal point, and expect a majority of voters to support their proposal. This is the subgame-perfect equilibrium of the game. No one can do better by unilaterally switching to another strategy.

Nevertheless, subjects may not consider the possibility of waiting 15 min before making the first proposal because they may believe it violates a political norm. In which case, we would expect subjects to propose and vote on alternatives until they arrive at point A, similar to our VTA treatment. Since a majority of voters prefer point A to every other point in the space, groups using TSR should move to A within the time limit.

Our third stopping rule is the Chair Decides to Adjourn (CDA). Voting in this treatment stops when a specified person chooses to adjourn. In our experiment that person is Player E, the player farthest from the majority-rule core. By making Player E the chair, we intentionally create tension between Player A's ideal point (the majority-rule prediction) and Player E's ideal point (the ideal point farthest from the majority-rule prediction).

We predict that groups using CDA will discontinue voting at a point on line segment $\overline{AE}$. This segment is the core of the CDA game (i.e., for every point on $\overline{AE}$ there does not exist another point that a decisive coalition prefers to it). To see why, note that a decisive coalition in the CDA game must contain three voters, one of which is E. Otherwise, the game will continue. Coalitions $c_1 = \{A, B, E\}$, $c_2 = \{A, D, E\}$, and $c_3 = \{A, C, E\}$ are the only ones fitting this description. Ordeshook (1986) shows that for any simple voting game the core is at the intersection of the convex hulls of all decisive coalitions. That intersection is $\overline{AE}$. If the group was at any point not on $\overline{AE}$, a majority which includes Player E would receive greater utility from moving to *some* point on $\overline{AE}$. Once a point on $\overline{AE}$ is attained, a majority that includes E could not do any better by leaving that location. We relate these predictions to bargaining theory in Appendix A.

For Series 2, the subgame perfect equilibrium for TSR continues to be the first proposer holds onto the proposal until time has almost expired then proposes their own ideal point which a majority of other players accept. For CDA, the core is uniquely point E, where all decisive coalitions intersect. Hence, we predict CDA groups should end closer to E in Series 2 than they do in Series 1. We do not have a precise prediction for VTA because the majority-rule core is empty in this case. Instead of making a prediction for VTA, we evaluate how far groups deviate from the majority core in Series 1.

4. Experimental design

We recruited 245 subjects from the University of Georgia, primarily from Introduction to American Government classes (a required course for all university students), a college listserv, and flyers posted around campus.[5] A maximum of 15 subjects were used per experimental session, which we broke into groups of five. All subjects were paid a $5 show-up fee including alternates who do not participate in the experiment. Subjects could earn up to 1000 points during the experiment for getting their group to choose an outcome at their ideal position and fewer points for outcomes father away.[6] Points were exchanged for dollars at a rate of $1 for every 55.56 points, allowing subjects to earn up to $18 from the experiment plus the $5 show up fee. Subject email addresses were collected prior to the experiment to ensure that a subject did not participate more than once. In the end, we had eight groups of five subjects for five of our treatments and nine groups for one of our treatments (Series 1, TSR).[7]

At the beginning of each session, subjects were asked to sit in front of a computer with written instructions and a consent form laying next to it, face down. Subjects were grouped pseudo-randomly using a computer interface written in z-tree (Fischbacher, 2007). They maintained the same player position and group throughout the experiment.

Subjects, including alternates, were then asked to read the consent form. If a subject chose to not participate, one of the alternates would take their place. Students who participated were then asked to read the instructions simultaneously while alternates were paid the $5 show up fee. After everyone read the instructions, subjects took a short, four-question quiz on their computer that helped determine how well they understood the payoff structure.[8] Each group then went through a series of practice rounds, followed by the experimental rounds – both of which applied the stopping rule for their treatment

[5] See Appendix B for a description of the demographic composition of our subjects.

[6] We use the following payoff function for all subjects:

$$\text{points} = 1000 \cdot exp(-\sqrt{(x-\theta_1)^2 + (y-\theta_2)^2}/55),$$

where (θ_1, θ_2) is the subject's ideal point and (x, y) is the outcome chosen by the group.

[7] We added an additional Series 1, TSR group after discovering an outlier in that treatment.

[8] We found no relationship between group choice and performance on the quiz.

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(see below). The practice and experimental rounds were identical except the initial status quo was (10, 10) in the practice rounds and (190, 140) in the experimental rounds. The practice rounds also were typically shorter.[9]

During the experiment, each member was randomly assigned an ideal point in a two-dimensional space that all members of the group could see. At the beginning of every round, the computer randomly picked one member of the group to be the proposer for that round, which other members of the group could also see. Before making a proposal, proposers could click on various locations in the space showing the payoffs associated with that point and the payoffs from the status quo for all of the players. Proposers could propose any point in the space. If they proposed something other than the status quo, the committee then voted on the proposed point versus the status quo.[10] Subjects were shown how each subject voted on the next, interim-results screen. In the VTA and CDA treatments, subjects also proposed to adjourn on the interim-results screen. When time expired under TSR or the group decided to adjourn under VTA or CDA, subjects were shown their final payoff in dollars on the final results screen.

In all of our treatments, the winning alternative became the status quo in the next round. No communication was allowed other than that which could be inferred through play.[11] All 49 groups followed the procedures listed above in exactly the same way. They differed only by the set of ideal points (Series 1 versus Series 2) and the stopping rule.

For Vote to Adjourn (VTA), all subjects were given the option to propose to adjourn on the interim results screen, which includes the warning "NOTE: Choosing to adjourn means ending the experiment. If the experiment ends now, points will be based on the previous round." If a subject proposed to adjourn, a window appeared on the same screen allowing other members of the group to vote to "continue experiment" or to "end experiment." After all subjects voted for or against adjournment, another screen appeared showing the results of the vote to adjourn, including how each player voted. If a majority decided to continue, the group moved to the next round. If they decided to adjourn, the group went to the final results screen.

For Timed Stopping Rule (TSR), groups had 15 min to propose and vote on as many alternatives as they desired. In this treatment, the remaining time was shown in the upper-right hand corner of each screen in seconds. If the time limit was reached in the middle of a round (i.e., before a proposal had been made or voting on a pair of proposals had been completed), "Time Expired. Final Round" appeared in place of the remaining time and the group was allowed to finish voting. Hence, the actual length of the TSR treatment varied by group and slightly exceeded 15 min. In this treatment, the interim results screen only included information about how members of the group voted in the previous round. When the last round of voting was complete, subjects were shown the final payoffs screen.

Chair Decides to Adjourn (CDA) was very similar to VTA, except Player E was the only subject given the option to adjourn on the interim results screen. If Player E decided to continue, subjects were shown a screen displaying E's decision, then moved to the next round. If Player E proposed to adjourn, subjects were shown Player E's decision followed by the final payoffs screen. To avoid any deference to Player E, we never referred to him/her as "chair." We only noted that Player E had the sole power to adjourn.

After the experiment had ended, subjects were asked to complete a demographic survey that included an open-ended request for additional comments and perceptions. The quotes reported below are responses to that question.

5. Results

5.1. Series 1 results

Our results suggest that stopping rules can affect decisions made by committees, particularly committees that stop using CDA versus non-CDA. Fig. 2 shows the final policy outcomes for the 49 groups in our study.

Consider Series 1 in the top row of the figure. Both the VTA and the TSR groups stopped voting near A (the majority-rule core), while CDA groups ended almost twice as far from A. The average distance between the final outcome and A is 7.7 units for VTA, 22.6 units for TSR, and 52.7 units for CDA. Without Group 8, the outlier in frame B of Fig. 2, the TSR distance is 4.4 units, suggesting that the VTA and TSR groups ended substantially closer to the majority-rule core than the CDA groups without that outlier (more about the outlier later).[12]

Our treatments had an effect on the distance to Player E as well. The average VTA and TSR groups ended 134.9 and 131.7 units away from Player E's ideal point, respectively. The CDA groups ended 80.0 units away. Although CDA did not always produce Player E's ideal point, nor was it expected to, it did produce outcomes significantly closer to E than the other two treatments combined.[13]

[9] We asked groups using VTA or CDA to adjourn during the practice rounds if they continued for more than 10 min. Those groups could adjourn more quickly in the experimental rounds if they chose to adjourn sooner. TSR groups had 5 min for the practice rounds and 15 min for the experimental rounds. Hence, they always had less time to practice.

[10] We assume proposers always favor their proposals. Hence, we do not physically ask them to vote for their own proposal.

[11] We do not allow communication because it could affect our treatments unevenly. For example, there might be more aggressive communication in CDA groups, badgering player E into adjourning, than in the other two treatments.

[12] The difference of means between CDA and non-CDA is significant at the 0.05 level with the outlier and at the 0.01 level without the outlier.

[13] The difference of means between CDA and non-CDA is significant at the 0.01 level.

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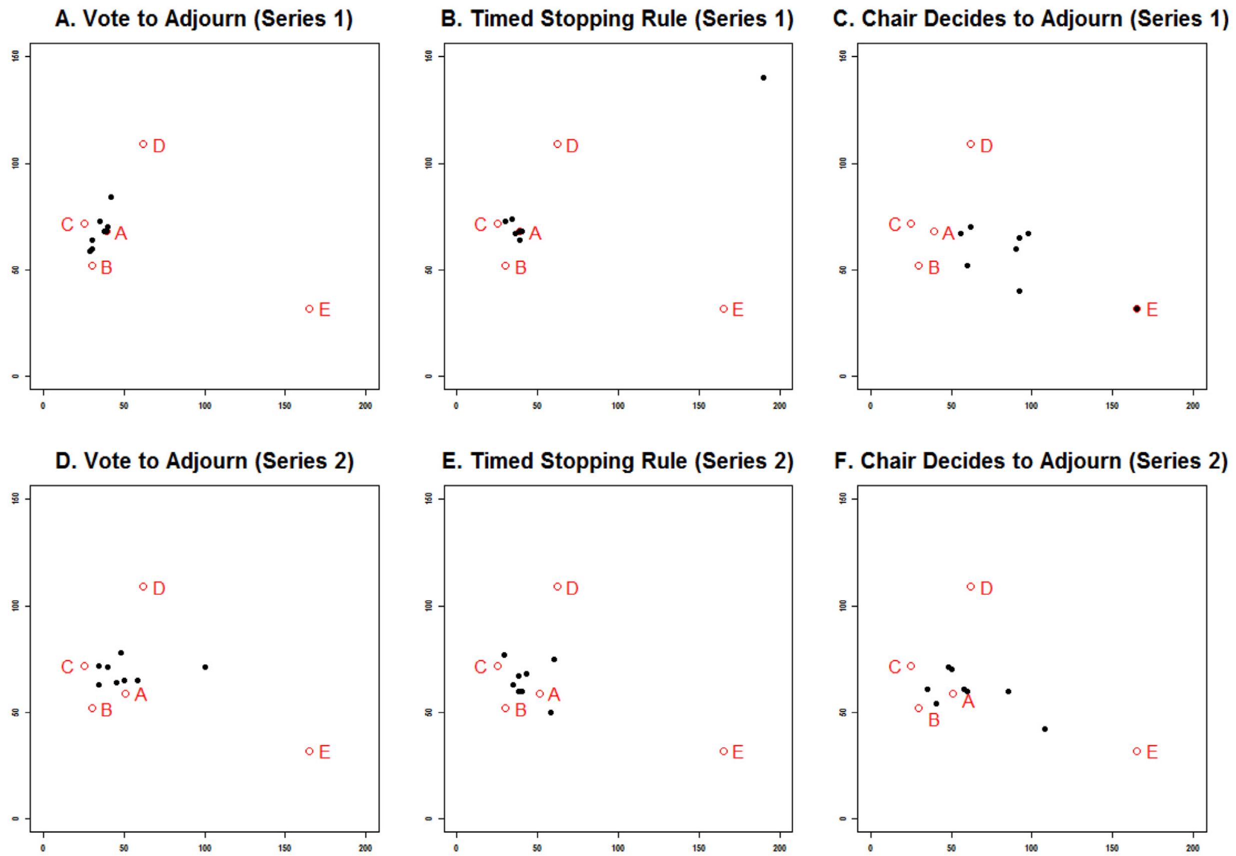

Fig. 2. Final Outcomes. *Note*: See Appendix B for a list of final outcomes by group.

Furthermore, groups voted longer using CDA. VTA groups voted for an average of 7.8 rounds and TSR groups voted for an average of 11.7 rounds. Compare that to the CDA groups, which voted for an average of 32 rounds, roughly three times as long. One CDA group went so far as to record 98 rounds before adjourning.[14] In addition to voting for more rounds, CDA groups spent more time in the experiment than the other two groups, taking an average of 22.1 min, compared to 9.9 min for VTA and 16.3 min for TSR.

Fig. 3 shows the progression of three groups through the space, each representing one of the three treatments. 45 of the 49 groups made an initial proposal within the Pareto set (i.e., within the convex hull). Most of these proposals were in the vicinity of A, B, and C for the VTA and TSR treatments, while many of the initial proposals for the CDA groups were in the vicinity of $\overline{AE}$, as in Fig. 3, Frame C. Groups then wandered in the vicinity of the first proposal that passed.

Interestingly, there was no first proposer advantage for groups using VTA or TSR, but there was a first proposer advantage for groups using CDA. For both the VTA and the TSR groups, subjects who were randomly selected as the initial proposer ended farther from the final outcome on average than other members of their group. If there was a first proposer advantage, first proposers would end closer to the final outcome, not farther. However, in our CDA groups, first proposers averaged 26.9 units closer to the final outcome than other members of their group – a significant difference at the 0.05 level. The result is consistent with our theory for CDA. We expect our Series 1, CDA groups to end on $\overline{AE}$, the relative position of which can be affected by which subject proposes first. For example, in Group 18, Player E was the first proposer; she proposed her ideal point, which passed, then she discontinued voting. In Group 21, Player A was the first proposer; he proposed an outcome roughly 23 units northeast of his ideal point, which passed, then Player E discontinued voting – perhaps because E was worried the group would move farther from his ideal point.[15]

[14] We had to artificially stop four of our CDA groups at least one hour and twenty minutes after the start of the experiment: groups 17, 24, 25, and 28. The first was a Series 1 group, the latter three were Series 2. We did this because all subjects were expected to leave the experiment at the same time, one subject asked to leave for a class, and another session ran into the time allotted for a later session. Excluding these groups has almost no effect on the final location of Series 1 CDA, but it produces final locations that are closer to E and farther from A for Series 2 CDA.

[15] With all treatments and periods pooled, players C and E took longest to propose (roughly 45 seconds); Player A took the least amount of time (roughly 32 seconds) – a significant difference at the 0.05 level. For Series 1, CDA groups proposed a bit faster on average than the other two treatments partly because proposers in CDA groups were less likely to reflect on their motions if the game continued for many rounds. Player E took the most amount of

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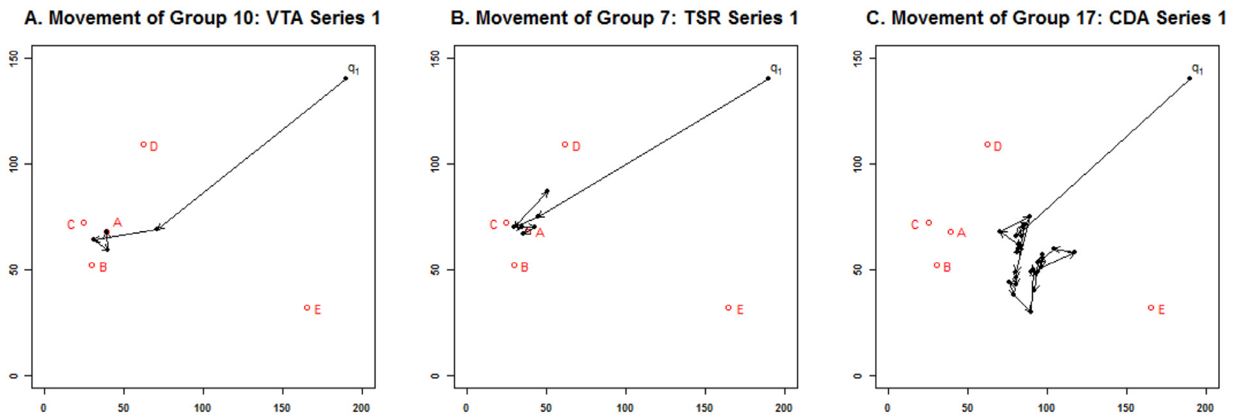

Fig. 3. The Movement of Three Groups.

Furthermore, there was a fair amount of cycling among alternatives outside of the majority-rule core. For example, Group 7 (depicted in Fig. 3, frame B) moved to (30,70) in round two and to (51, 87) in round three, only to move right back to (30, 70) for the next three rounds.

5.2. Series 1 hypotheses

Our study provides clear evidence in favor of our hypothesis that VTA groups will choose the majority-rule core as the final outcome in Series 1. Three of the eight VTA groups were within five units of A, one of which made it to A exactly. As mentioned previously, the other groups were close.

Our theory for TSR performed poorly. We expected the first proposer to hold on to the right to propose until the final seconds, then propose his or her ideal point, which a majority would accept. With the exception of Group 8, none of our groups attempted to do this. In Group 8, Player E was randomly chosen as proposer in the first round. He waited until time was about to expire, then proposed his own ideal point which would have given players A, B, and C at least 32 more points than the status quo. However, players A, C, and D all voted for the status quo instead, leaving the final outcome at the initial status quo. Fairness seemed to affect their decision. Player A wrote, "Just the idea of letting E win after waiting us all out for their little game was utterly repulsive to me." Player D called it "spite." Player B, who voted for the proposal, wrote "I think that this happened because all of the other players were angry at being on the losing side (including myself) and they manifested this in a status quo vote. Even though it was technically against their best interest to do so." This explains the outlier in Fig. 2, frame B. That outlier is the only group that attempted to behave according to the subgame-perfect-equilibrium prediction for our TSR game.

Such a strategy may have been less obvious to the other TSR groups. Nothing in the instructions suggested that proposers could hold onto proposals as long as they wanted and nothing forbade it.[16] Subjects may have proposed in a timely fashion because political norms suggested that was the proper behavior. If waiting to propose until time is about to expire is excluded from the strategy set, then we would expect TSR groups to end voting at or near the majority-rule core. With the exception of Group 8, most of our TSR groups did just that.

Our theory for CDA was that Series 1 groups would select an outcome on $\overline{AE}$ at the end of the game. Although only one group selected a point exactly on $\overline{AE}$, CDA groups ended an average of 8.4 units away, consistent with our theory. That distance did not get smaller with more rounds of play.[17] In Group 18, Player E ended the game in the first round after her group chose a position on $\overline{AE}$. In Group 17, Player E continued the game for 98 rounds producing an outcome 12.4 units away from $\overline{AE}$ – the second largest distance from $\overline{AE}$ for Series 1, CDA groups. One might expect the opposite if longer play brought groups closer to equilibrium.

Another reasonable conjecture is that Player E would be more successful if he/she held out longer, implying a negative relationship between the distance to E and the number of rounds. However our groups did not exhibit this behavior. The distance between E's ideal point and the final outcome is positive and insignificantly correlated with the number of rounds at 0.22, not negatively correlated.

time to propose in CDA groups (roughly 31 seconds), while Player A took the least amount of time to propose (roughly 20 seconds) – a difference that is significant at the 0.01 level. Subjects assigned Player E may have taken longer to propose than other subjects because the position required additional time to reflect on proposals that both they would desire and a majority would accept.

[16] The written and verbal instructions are reproduced in Supplement Information.

[17] The projected distance from $\overline{AE}$ is correlated with the number of rounds at −0.04 among the eight Series 1 groups and at 0.19 among the sixteen Series 1 and Series 2 groups combined. Neither correlation is significant.

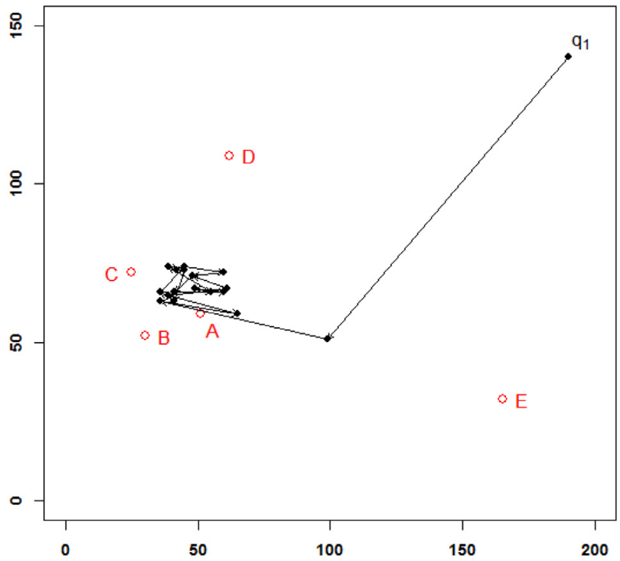

Fig. 4. Movement of Group 25 (Series 2, CDA).

5.3. Series 2 hypotheses and results

Our Series 2 ideal points are the same as our Series 1 ideal points, except the ideal point for Player A is (51,59), not (39, 68). As can be seen in the three bottom frames of Fig. 2, the final outcomes under Series 2 are fairly similar to the final outcomes under Series 1.[18]

Although we do not have a clear prediction for Series 2, VTA, we can compare the performance of those groups to the prediction for Series 1, VTA. To do so, let $A' = (39, 68)$, the location of A in Series 1. VTA groups ended the game surprisingly close to A′ in Series 2, consistent with the findings of Fiorina and Plott (1978). The average distance to A′ was 16.1 units in Series 2 compared to 7.7 units in Series 1.[19]

Our prediction for TSR continued to perform poorly. We expected the first proposer to hold on to the right to propose until the final seconds, then propose his or her ideal point, which would pass. None of the proposers in our Series 2, TSR groups behaved this way. Each proposed in a timely manner as if they wanted to allow others to propose. The groups also ended fairly close to A′. Groups ended 11.2 units away from A′ for Series 2 compared to 22.8 for Series 1 (4.8 without the Series 1 outlier).

Our CDA groups did not behave as expected either. We expected those groups to end at Player E's ideal point – the unique CDA core for Series 2. However, they were no closer to E in Series 2 than they were in Series 1. Our Series 2 groups ended an average of 108.2 units away from E compared to 80 units for Series 1, a significant difference at the 0.01 level.

As with Series 1, chairs did not earn more points by forcing more votes. The distance between Player E's ideal point and the final outcome is correlated with the number of rounds at 0.59 – that number should be negative if continuing the experiment increased points for Player E. A perfect example of this phenomena is Group 25 (see Fig. 4). Player E was selected as the initial proposer in the first round and proposed a position near $\overline{AE}$, which passed. Rather than discontinue voting immediately, Player E chose to continue the experiment to the advantage of the other members of her group. Player D proposed a point near A in the very next round, which passed. The group then proposed and passed a series of proposals in the vicinity of A or chose to remain at the status quo. Player E was so frustrated by the experience that she continued the game for a total of 60 rounds. Player A wrote, "There needs to be a way to stop the game or pick a better E, because our game went on forever for no reason. We were getting no where."

Despite the poor predictive power of the core for this treatment, there were significant differences between CDA and non-CDA groups in Series 2. CDA groups ended roughly twice as far from A′ as non-CDA groups and closer to E, differences that are significant at the .01 level. Furthermore, CDA groups spent more than twice the time in the experiment as non-CDA groups and continued for more than twice the number of rounds. The average CDA group ended after 29.3 rounds, VTA after 11.1 rounds, and TSR after 12.8 rounds. Surprisingly, CDA groups ended closer to $\overline{A'E}$ in Series 2 than in Series 1.

[18] All of our Series 2 groups ended in the Pareto set, fifteen of them ended in the uncovered set (63%), and seven ended in the yolk (29%).

[19] The outlier shown in the bottom-left frame of Fig. 2 is Group 35. Players in this group described their final outcome as "fair." Player D proposed (100, 71) in the first round, which unanimously passed. Players A, C, and E then voted to adjourn. Player A commented, "The points seemed to be distributed fairly equally amongst my fellow group members, which was satisfying." Player B wrote, " it is important to me that all participants get a relatively equal sum given their assigned location, especially since we are profitting regardless."

6. Conclusion

Our results suggest that the type of stopping rule used by a committee can impact its decisions. Although we find few differences between voting to adjourn and timed voting, committees that allow a chair to determine adjournment choose outcomes much farther from the majority-rule core than committees using one of the other two stopping rules. And they are more likely to produce outcomes that favor the chair. Ironically, it is the chair's power to adjourn that produces outcomes in her favor, not her excessive use of that power. Chairs that hold a committee hostage by not adjourning are not more successful.

These findings are important for the large experimental literature on voting in committees. Although the institution is subtle, stopping rules can affect experimental outcomes. Experimentalists should think about these issues when they create new experimental designs.

Moreover, majority rule is ubiquitous in town councils, school boards, and corporate meetings, to name a few. The rules that stop voting in those cases have to be considered just as much as the voting rule itself. If a committee is under pressure to reach a decision quickly, they might seek to implement a timed stopping rule to meet a hard deadline. If they want to make a majority of committee members satisfied with the committee's decisions, they might consider voting to adjourn as well. And if a key member, such as an executive surrounded by a council of advisors, wants to guarantee outcomes closer to their own preferences, that member might give themselves the power to adjourn. In some cases, this might be desirable. In others, this dictatorial stopping rule may be too undemocratic to warrant adoption.

Appendix A

In this appendix, we follow the suggestion of a reviewer and relate our predictions for Series 1 to stationary subgame perfect equilibria (SSPE) from the literature on bargaining games (Baron and Ferejohn, 1989). Banks and Duggan (2000) prove the existence of no delay, SSPE in spatial voting games. However, there are important differences between their game and our own. They assume that a randomly selected proposer j makes a proposal x_t^j in round t. If x_t^j passes, the game ends and every player i receives $u_i(x_t^j)$. If the proposal fails, another randomly selected proposer k proposes x_{t+1}^k in $t+1$. If a proposal never passes, all players receive zero utility. In our game, the initial status quo does not give everyone a payoff of zero and passing a proposal does not terminate the game.

If one believes these differences are inconsequential, then one can use the Banks and Duggan (2000) model to find no delay SSPE for our VTA and CDA games.[20] Notably, Banks and Duggan (2000) show that if all players are perfectly patient (i.e., they don't discount future payoffs) and the voting rule is collegial (i.e., the intersection of decisive sets is non-empty), then there is full equivalence between the core and no delay SSPE. Such SSPE are described in the text. SSPE deviate from the core as individual discount rates $\delta_i \in [0, 1]$ approach zero.

To see specific equilibria for $\delta_i = 1$, and additional equilibria for $\delta_i < 1$, we need some notation.

For VTA, the set of decisive, or minimum winning, coalitions can be defined as:

$$\mathcal{D}^{VTA} = \left\{ c \subseteq N \middle| |c| > \frac{n}{2} \right\},$$

where $N = \{1, \ldots, n\}$ is the set of individuals and c is a coalition of those individuals.

For CDA, the set of decisive coalitions can be defined as:

$$\mathcal{D}^{CDA} = \left\{ c \subseteq N \middle| (|c| > \frac{n}{2}) \wedge (E \in c) \right\}.$$

In SSPE each player j is recognized as proposer with a probability ρ_j and propose x^j. In our case $\rho_j = 1/5$. Player i votes for x^j if and only if their utility from x^j is at least as great as their utility from rejecting the proposal and continuing to the next round of the game. More precisely, individual i accepts x^j if and only if $u_i(x^j) \geq \delta_i v_i$, where v_i is player i's continuation value:

$$v_i = \sum_{j=1}^{5} \frac{1}{5} u_i(p_j).$$

To simplify the analysis, we focus on series 1 and re-scale the ideal points such that A is at the origin and the other four ideal points are rotated counterclockwise until C and E are on the x-axis.[21] This preserves the relative distance between points but simplifies that analysis considerably. Rounded to three digits, the transformed ideal points are A = (0.000, 0.000), B = (−4.258, −17.857), C = (−14.560, 0.000), D = (10.851, 45.741), and E = (131.042, 0.000).

[20] Banks and Duggan (2006) conduct a similar analysis with a status quo. However, players in their model receive utility from the status quo for *every* period in which a proposal does not pass, which is not the case in our game. Players in our game only receive payoffs from the final period, similar to Banks and Duggan (2000).

[21] Note that $\angle DAE < 90°$.

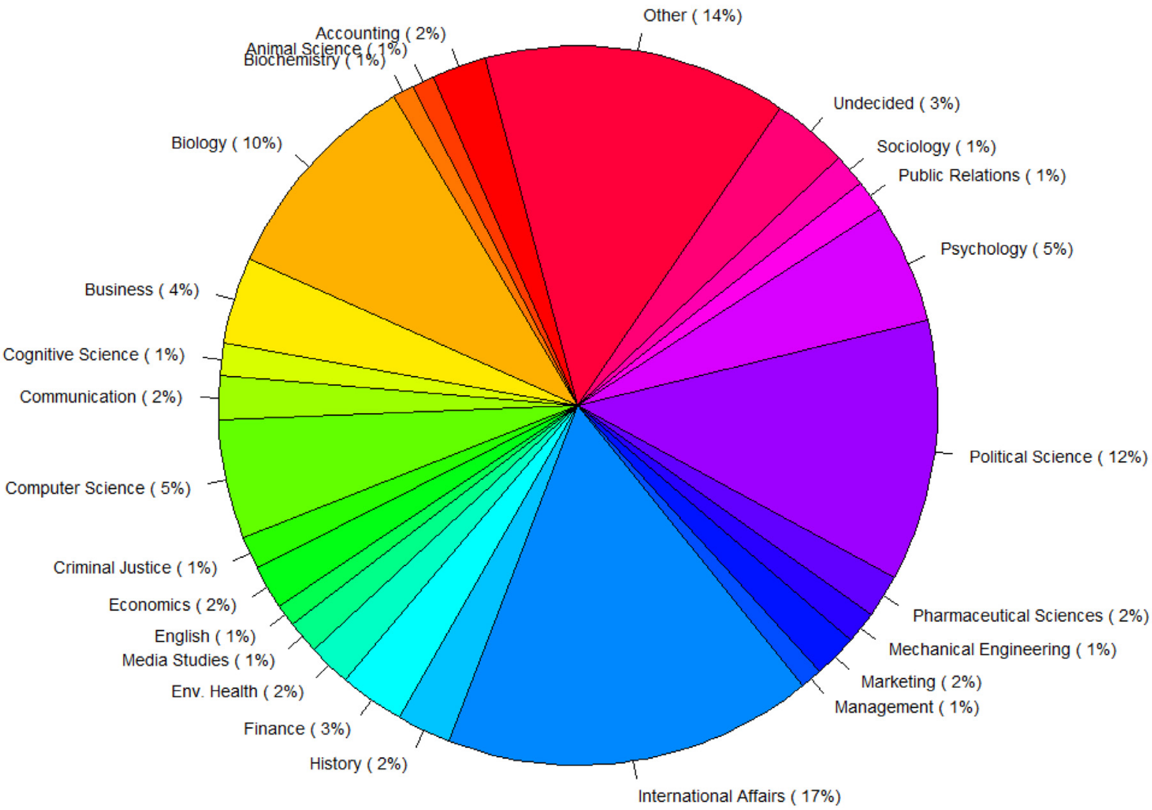

Fig. 5. Pie Chart of Majors.

Example 1. We first consider a no delay SSPE for VTA in which $\delta = \delta_A, \ldots, \delta_E$ and players make the following proposals in pure strategies: $p_A = (0, 0)$, $p_B = (-4.258\alpha_B, -17.857\alpha_B)$, $p_C = (-14.560\alpha_C, 0)$, $p_D = (10.851\alpha_D, 45.741\alpha_D)$, and $p_E = (131.042\alpha_E, 0)$, where $\alpha_i \in (0, 1]$. With $\delta = 1$, the unique SSPE is $\alpha_i = 0$. That is, everyone proposes the core which a decisive coalition accepts. With $\delta < 1$ there are other equilibria, one of which can be attained by setting α_i such that each proposal is the same distance from the origin as Player C (14.560 units). In this case, a decisive coalition favors each proposal and no proposer has an unilateral incentive to make another proposal if $\delta \simeq 0.943$.

Example 2. Consider the same strategy profile for CDA. If $\delta = 0.943$, the strategy profile described above cannot be maintained as an equilibrium because E would not accept p_C or p_B. However, if α_i is set such that each proposal is 3.20 units away from the origin, a pure strategy SSPE can be maintained for $\delta = 0.943$. As $\delta \to 1$, $\alpha_i \to 0$ in equilibrium.

Example 3. Note that 131.042 is the length of $\overline{AE}$. If $\delta = 1$, any point on $\overline{AE}$ can be maintained as a SSPE of the CDA game if all players propose the same point. However, if A…D propose $p_j = (131.042\alpha_j, 0)$, E proposes $p_E = (131.042\alpha_E, 0)$, and $\alpha_j < \alpha_E$, there would not be a SSPE for $\delta = 1$ because E would reject p_j as producing less than her continuation value. Nevertheless, an equilibrium could be maintained for $\delta < 1$. One such example is $\alpha_j \simeq 0.915$ and $\alpha_E = 1$ for $\delta_j = 0.849$ and $\delta_E = 0.900$. In this case, E can propose her own ideal point while the other players propose a point closer to A because she is more patient than the other four players.

Such examples relate SSPE to the core and support the existence of equilibria in the neighborhood of the core. Undoubtedly other SSPE exist.

Appendix B

Our subjects were diverse. Among the 245 subjects studied 60% were women. In addition, 42% were freshmen, 21% were sophomores, 18% were juniors, and 13% were seniors. The remaining 13 subjects were either graduate students, super-seniors, or withheld that information. While more than half of the subjects identified themselves as Caucasian (54%), 22% were Asian or Pacific Islander, 13% were African American, and 7% were Hispanic. Most majored in International Affairs (15%) or Political Science (13%). Nevertheless, subjects came from a wide variety of disciplines including Biology, Computer Science, and Psychology (see Fig. 5).

Subjects were assigned to the groups listed in Table 1.

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Table 1
Final outcomes by group.

Group	Treatment	Series	Final outcome	Group	Treatment	Series	Final outcome
2	TSR	1	(39, 64)	27	CDA	2	(60, 60)
3	TSR	1	(39, 68)	28	CDA	2	(41, 54)
4	TSR	1	(30, 73)	29	VTA	2	(58, 65)
5	TSR	1	(34, 74)	30	VTA	2	(40, 71)
6	TSR	1	(39, 68)	31	TSR	2	(29, 77)
7	TSR	1	(36, 67)	32	TSR	2	(38, 67)
8	TSR	1	(190, 140)	33	TSR	2	(58, 50)
9	TSR	1	(40, 68)	34	VTA	2	(34, 72)
10	VTA	1	(39, 68)	35	VTA	2	(100, 71)
11	VTA	1	(30, 64)	36	CDA	2	(108, 42)
12	VTA	1	(30, 60)	37	TSR	2	(35, 63)
13	VTA	1	(38, 68)	38	TSR	2	(38, 60)
14	CDA	1	(92, 65)	39	TSR	2	(40, 60)
15	CDA	1	(98, 67)	40	TSR	2	(43, 68)
16	CDA	1	(90, 60)	41	VTA	2	(34, 63)
17	CDA	1	(92, 40)	42	VTA	2	(45, 64)
18	CDA	1	(165, 32)	43	VTA	2	(50, 65)
19	CDA	1	(56, 67)	44	TSR	1	(30, 70)
20	CDA	1	(60, 52)	45	TSR	2	(60, 75)
21	CDA	1	(62, 70)	46	VTA	1	(29, 59)
22	CDA	2	(85, 60)	47	VTA	1	(40, 70)
23	CDA	2	(35, 61)	48	VTA	1	(35, 73)
24	CDA	2	(50, 70)	49	VTA	1	(42, 84)
25	CDA	2	(48, 71)	50	VTA	2	(48, 78)
26	CDA	2	(58, 61)				

Note: Groups are numbered chronologically. The results for Group 1 were discarded because the computer network froze during that session.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2018.04.014.

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